

Improving Utilization of Sputum Culture in Patients Hospitalized with Pneumonia: A Quality Improvement Initiative

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ABSTRACT

Background: Sputum cultures are essential for guiding targeted antibiotic therapy; however, they are often underutilized. This quality improvement initiative aimed to enhance sputum culture ordering through an antimicrobial stewardship pharmacist-led intervention.

Methods: A retrospective review of pneumonia hospitalizations from January 2021 through December 2022 evaluated the impact of a policy change allowing antimicrobial stewardship pharmacists to order sputum cultures. Statistical analyses compared preintervention and postintervention sputum culture ordering rates, adjusting for patient demographics, hospital admission location, and other covariates.

Results: Sputum culture orders increased from 36% before the intervention to 50% after the intervention, with a 29% higher likelihood of sputum culture ordering after the intervention (risk ratio, 1.29; 95% CI, 1.19–1.38; $P < .001$).

Conclusions: This intervention demonstrates the potential for antimicrobial stewardship programs to improve adherence to guideline-based practices through pharmacist-led initiatives.

BACKGROUND

In the National Hospital Care Survey, pneumonia accounted for 130 657 qualifying pneumonia hospitalizations across the United States in 2016, with a 35% in-hospital mortality rate.¹ Along with increased morbidity and mortality, pneumonia is associated with significant clinical and economic burdens resulting from prolonged hospitalization and high medical costs. Methods for diagnosing community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP) include sputum cultures, antigen tests, blood cultures, polymerase chain reaction, and invasive techniques such as

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thoracocentesis, transthoracic needle aspiration, and bronchoalveolar lavage.²

The American Thoracic Society (ATS)/Infectious Diseases Society of America (IDSA) 2019 guidelines for community-acquired pneumonia recommend performing a sputum culture for patients with severe pneumonia and for all inpatients being treated empirically for methicillin-resistant *Staphylococcus aureus* (MRSA) or *Pseudomonas aeruginosa* (*P aeruginosa*). Specifically, for intubated CAP patients unable to produce lower respiratory tract specimens and those who previously received treatment for MRSA or *P aeruginosa*, immediate sputum cultures are recommended.³

Noninvasive sputum cultures have been found to be useful for identifying the pathogenic bacteria responsible for pneumonia, guiding timely and accurate antibiotic selection, and supporting successful treatment outcomes.^{4,5}

Previous literature has demonstrated that sputum culture use is associated with improved intensive care unit (ICU) mortality, decreased antibiotic usage, fewer adverse effects, reduced cost, and shortened hospital length of stay.^{1,6,7} Despite controversy surrounding sputum culture use due to concerns about sample representativeness and contamination, previous studies have reported increased ICU and hospital mortality among pneumonia patients without sputum culture collection.⁶ When compared with invasive bronchoalveolar lavage for definitive diagnosis, sputum cultures are less time-consuming, more cost-effective, and have a 96.5% positive predictive value (PPV).⁸ Previous quality improvement (QI) projects have reported improved compliance with established pneumonia performance indicators after implementation of a sputum culture order set, as well as improvements in overall CAP prognosis. Recent research on multidisciplinary, stewardship-led interven-

tions to improve sputum culture utilization is limited.^{9,10} Based on evidence supporting the role of sputum culture in pneumonia treatment and prognosis, this QI initiative aimed to enhance sputum culture collection through an antimicrobial stewardship pharmacist-led intervention at Catholic Health Initiatives (CHI) Health Creighton University Medical Center in Omaha, Nebraska.

METHODS

A retrospective chart review was conducted of adult patients admitted to CHI Health Creighton University Medical Center with CAP or HAP from January 1, 2021, through December 31, 2022. Patients transferred to another facility or who died within 48 hours of admission were excluded. This QI project was reviewed by our local Institutional Review Board (IRB) and was determined not to constitute human subjects research (reference No. 2001933-01); therefore, IRB approval was not required.

Intervention

On November 1, 2021, a system-wide initiative allowed antimicrobial stewardship pharmacists to order sputum cultures, a role previously limited to physicians. The intervention was initiated following approval by the hospital's Clinical Policy Committee and endorsement by the Quality Improvement Committee. Implementation steps included developing a concise clinical rationale and presenting it at 3 multidisciplinary QI meetings, engaging internal medicine residents and hospitalists as QI champions to facilitate adoption, and implementing a system-wide policy change enabling stewardship pharmacists to order sputum cultures.

The postintervention period was defined as January 1, 2022, onward to account for implementation adjustments. The data for this 2-month implementation period from November-January has been censored.

Analysis

Descriptive patient characteristics are reported as frequencies and percentages for categorical variables and as medians and interquartile ranges for continuous variables. Patient characteristics were compared between preintervention and postintervention periods using chi-square tests for categorical variables and Mann-Whitney tests for continuous variables. Log-binomial regression was used to estimate the adjusted likelihood of having a sputum culture ordered before versus after the intervention. Covariates included patient age at admission, sex, Hispanic ethnicity (yes/no), hos-

Table 1. Overall Patient Characteristics

Patient Characteristics	Overall (N = 3614) Frequency (%)	Preintervention Frequency (%)	Postintervention Frequency (%)	P value
Age (Median, IQR)	68 (57–70)	67 (55–78)	70 (60–79)	<.001
Female	1694 (47%)	1002 (47%)	692 (46%)	.60
English language	3336 (92%)	1953 (92%)	1383 (93%)	.57
Hispanic ethnicity	284 (8%)	179 (8%)	105 (7%)	.15
Missing	123 (3%)	62 (3%)	61 (4%)	
Department				0.004
Intensive care unit	668 (18%)	425 (20%)	243 (16%)	
Medical/surgical unit	2946 (82%)	1696 (80%)	1250 (84%)	

Table 2. Sputum Test Ordered (N = 3614)

N = 3614	Risk Ratio (95% CI)	P value	Adjusted Risk Ratio (95% CI)	P value
Postintervention vs Preintervention	1.30 (1.21–1.40)	<.001	1.29 (1.19–1.38)	<.001
Medical/surgical unit vs intensive care unit	1.26 (1.16–1.37)	<.001	1.25 (1.15–1.37)	<.001
Male vs female	1.05 (0.97–1.13)	.25	1.02 (0.95–1.11)	.55
Other vs English	1.05 (0.91–1.21)	.47	1.13 (0.95–1.35)	.12
Other vs Hispanic	1.04 (0.90–1.20)	.61	1.10 (0.92–1.32)	.28
Age – 5 years	1.00 (0.98–1.01)	.44	0.99 (0.98–1.01)	.35

pital admission location (medical-surgical unit vs ICU), and patient primary language (English vs other). Results are presented as unadjusted and adjusted relative risks (RR) with 95% confidence intervals (CIs). All analyses were conducted using Statistical Analysis Software (SAS), version 9.4 (SAS Institute Inc), with statistical significance defined as 2-sided $P < .05$.

RESULTS

A total of 3614 patients diagnosed with pneumonia during the study period were included in the analysis. Of these, 2121 (59%) were diagnosed during the preintervention period, 1694 (47%) were women, and the median age at admission was 68 years. The majority of patients (82%) were admitted to a medical-surgical (med/surg) unit.

Overall, patient admission characteristics appeared similar between the preintervention and postintervention periods, suggesting that the underlying patient populations were comparable. However, a slightly higher proportion of patients were admitted to the med/surg unit in the postintervention period ($P = .004$), and patients in the postintervention period were slightly older ($P < .001$) (Table 1).

Sputum culture orders increased from 36% in 2021 to 42% in 2022, reaching 50% by 2023, highlighting the positive impact of the intervention on clinical practice. After adjustment for all covariates, the likelihood of sputum culture ordering was 29% higher in the postintervention period than in the preintervention period (RR, 1.29; 95% CI, 1.19–1.38; $P < .001$). Admission location was also a significant predictor, with patients admitted to

the med/surg unit having an estimated 25% greater likelihood of sputum culture ordering than patients admitted to the ICU (RR, 1.25; 95% CI, 1.15–1.37; $P < .001$). No other predictors were statistically significant (Table 2).

DISCUSSION

Our findings demonstrated a significant short-term increase in sputum culture orders for pneumonia patients following the implementation of a system-wide QI initiative.

Additionally, our analysis revealed that patients admitted to the med/surg unit had a 25% higher likelihood of having a sputum culture ordered compared with those admitted to the ICU. This finding aligns with prior studies, including a 2014 QI initiative among intubated pneumonia patients, which found that emergency department physicians rarely ordered sputum cultures—a practice associated with increased ICU mortality and reduced antibiotic de-escalation.⁷ These results suggest that further QI initiatives targeting ICU and emergency department providers could enhance adherence to evidence-based guidelines and ultimately improve patient outcomes.

There are limited data regarding sputum culture ordering among patients with CAP and HAP. This may be due to ongoing controversy surrounding the routine use of sputum cultures; despite their role in determining antibiotic susceptibility patterns and guiding treatment, they are often considered insufficiently accurate for diagnostic purposes. While some QI efforts have focused on decreasing mortality by increasing sputum culture utilization, there is little evidence evaluating the role of nonphysicians, such as antimicrobial stewardship pharmacists, in driving these improvements. Our system-wide initiative offers insight into how nonphysician-led interventions can influence adherence to best practices in pneumonia management.^{6,9,10} Our success may be attributed to several implementation strategies, including leveraging existing stewardship infrastructure, encouraging early stakeholder involvement, and clearly communicating the clinical rationale. The decision to empower pharmacists through a policy change required minimal resources and was broadly acceptable to physicians, facilitating rapid adoption. Although the intervention did not undergo multiple formal Plan-Do-Study-Act cycles, it represents a foundational model on which future, more iterative, and data-driven QI efforts can build. Disseminating not only outcomes but also implementation strategies and contextual factors may help address gaps in the literature regarding successful QI interventions.

Our study highlights the role of a robust antimicrobial stewardship program in successfully implementing guideline-based interventions. By promoting targeted therapy, such programs not only improve diagnostic accuracy and antibiotic selection but also help mitigate the growing threat of antibiotic resistance.

However, like other QI projects, our study has several limitations. Its quasi-experimental design limits the ability to establish direct causality, and statistical adjustments for clustering

effects—such as the influence of individual pharmacists managing multiple patients—were not incorporated. The impact of the COVID-19 pandemic on ordering practices was also not evaluated. Additionally, we did not quantify pharmacist time dedicated to the intervention or assess its cost-effectiveness, both of which could provide valuable insights into its economic impact. Furthermore, the generalizability of our findings may be limited in institutions without established antimicrobial stewardship programs, and we did not assess the impact of this intervention on patient outcomes.

Despite these limitations, our findings support the feasibility of low-cost, sustainable QI initiatives that drive meaningful changes in clinical practice. Future efforts should focus on identifying barriers to sputum culture utilization in ICU settings and developing tailored interventions to promote adherence to best practices in pneumonia management. Expanding evaluations of stewardship programs will be critical in demonstrating their long-term benefits in optimizing antimicrobial use, reducing resistance, and improving patient care.

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